3.1.4.1.2 Protection of the fixed service in the 17.7-19.3 GHz band

a) Characteristics of the fixed service systems in the 17.7-19.3 GHz band

The FS characteristics used for the evaluation of pfd limits for non-GSO FSS satellites in the 17.7-19.3 GHz band are given in the following:

Elevation angles	0 and 2.2°
Antenna height	0 metres
Antenna gain	32, 38 and 48 dBi
Antenna pattern	Recommendation ITU-R F.1245
Latitudes	25, 45 and 60°
Gaseous attenuation	Recommendation ITU-R SF.1395
Feeder loss	3 dB
Polarization loss	Note 7 of Recommendation ITU-R F.1245
Receiver thermal noise	-139 dB(W/MHz)

These characteristics are representative of a majority of links in that frequency range.

b) Fixed-service protection criteria in the 17.7-19.3 GHz band

The aggregate FS protection criteria in the 17.7-19.3 GHz band are given as follows in draft new Recommendation ITU-R F.[Doc. 9A/TEMP/64] to be submitted to RA-2000 for approval:

Long term: I/N = -10 dB not to be exceeded for more than 20% of the time.

Short term: I/N = +14 dB not to be exceeded for more than 0.01% of the time.

I/N = +18 dB not to be exceeded for more than 0.0003% of the time.

Note that the short-term criteria were established to protect sensitive FS links.

c) Methodologies used to assess the adequacy of the limits to protect the fixed service in the 17.7-19.3 GHz band

Many analyses using the pfd mask simulation method have been used for assessing the adequacy of the pfd limits for the protection of the FS. In this method, the statistics of the theoretical aggregate power levels received at an FS station are calculated by applying pfd limits under consideration to each visible satellite of the non-GSO FSS constellation. Annex 1 of Recommendation ITU-R F.1108 provides guidance on the calculation of visibility statistics of space stations operating in circular non-GSO orbits as seen by a terrestrial station.

In the derivation of the pfd limits defined in § 3.1.4.1.2 d), it was determined that if the calculated I/N results exceed the criteria of § 3.1.4.1.2 b) by no more than a few dB for worst-case geometries, this does not mean that the FS links would actually be impaired. It must be noted that the pfd mask analysis is overly conservative in that it computes interference (both long term and short term) that exceeds what would be produced by an operating non-GSO FSS system. This is because the analysis assumes that all the visible satellites of the non-GSO FSS constellation radiate simultaneously the maximum pfd limit, in the direction of the FS system under consideration, which is unrealistic. In addition, such an assumption does not take into account the patterns of the real satellite antenna, the power limitations of each satellite or the restrictions that self-interference would impose on a non-GSO system.

Calculations are made assuming that the FS receiver antenna is pointing in the direction of the worst-case azimuth for the non-GSO constellation under consideration, since in that pointing direction, the long-term and short-term power levels generated by the non-GSO constellation into the FS receivers are maximum.

Studies that have considered a more realistic modelling of the problem have produced results providing further evidence supporting that the pfd limits defined in § 3.1.4.1.2 d) are adequate. The method used takes into account some fundamental operational constraints of non-GSO FSS systems by using more realistic downlink models developed to generate pfd distribution profiles for a range of arrival angles which are used in place of the maximum-allowed pfd mask.

Given the methodology and assumptions used for evaluating the pfd limits, it can be assumed that the FS aggregate interference criteria given in draft new Recommendation ITU-R F.[Doc. 9A/TEMP/64], can be applied for each single non-GSO FSS constellation. These conclusions remain valid if the number of co-frequency non-homogeneous non-GSO FSS systems were in the range three to five.

d) Results of studies relating to the review/revision of the power limits appearing in Article S21 in the 17.7-19.3 GHz band

The following per satellite pfd limits (also described in draft new Recommendation ITU-R SF.[Doc. 4-9S/TEMP/94]) (submitted to RA-2000 for approval) are adequate for the protection of the FS in the 17.7-19.3 GHz band from aggregate interference from three assumed non-homogeneous, non-GSO FSS systems. Moreover, the contribution of GSO interference to the sharing has been shown as not being significant. Studies support and validate this conclusion. These results would remain valid if the number of non-GSO FSS systems were in the range three to five.

$-115 - X$	dB(W/(m^2·MHz)) for $0° \le \delta < 5°$
$-115 - X + ((10 + X)/20)(\delta - 5))$	dB(W/(m^2·MHz)) for $5° \le \delta < 25°$
-105	dB(W/(m^2·MHz)) for $25° \le \delta < 90°$

where δ is the angle of arrival above the horizontal plane and X is defined as a function of the number of satellites in the non-GSO FSS constellation, n, as follows:

for $n \le 50$	$X = 0$	(dB)
for $50 < n \le 288$	$X = (5/119)(n - 50)$	(dB)
for $n > 288$	$X = (1/69)(n + 402)$	(dB)

The scaling function, X, was developed on the basis of non-GSO FSS constellations with 96, 288 and 840 satellites. Further simulations with different non-GSO FSS constellations comprising a wide range in the number of satellites (63, 126, 189, 252 and 504 satellites) and using the conservative pfd mask simulation method have confirmed the adequacy of this scaling function.

Extensive studies have provided technical justification that the pfd limits above are certainly adequate to protect the FS from aggregate interference from the satellites of three to five, co-frequency non-GSO FSS systems operating in the 17.7-19.3 GHz band. Therefore these pfd limits are acceptable in that they protect the FS without unduly constraining the development of non-GSO FSS networks.

3.1.4.2 Protection of non-GSO FSS space station receivers from interference caused by FS systems in the 12.75-18.1 GHz frequency range and in the 27.5-28.6 GHz band

Studies have been undertaken to evaluate the interference from fixed-service systems into non-GSO FSS space stations in the bands where the two services are allocated on a co-primary basis in the 12.75-18.1 GHz frequency range and in the 27.5-28.6 GHz band.

3.1.4.2.1 12.75-18.1 GHz frequency range

The study was based on the characteristics of typical FS point-to-point systems and on the characteristics of the space stations of F-SAT MULTI 1B non-GSO FSS system. The study concluded that, even under pessimistic assumptions, the interference from FS systems into non-GSO FSS (Earth-to-space) in the 12.75-18.1 GHz frequency range would be acceptable.

3.1.4.2.2 27.5-28.6 GHz band

The study was based on the characteristics of typical FS point-to-multipoint systems and on the characteristics of the space stations of LEOSAT-1 non-GSO FSS system. The study considered the interference from high deployment of FS subscribers terminals into the main beam and the near side lobes of the non-GSO FSS satellite antenna. This study concluded that the interference levels would be acceptable since they are significantly lower than the generally agreed criterion. However, the study did not consider the aggregate impact of all transmitters located within the entire portion of the Earth visible to the satellite, the interference from a terminal's main beam into the side lobes of the satellite, or the interference between the FS hub transmitters using sectoral antennas into the non-GSO FSS satellite receiver. There was also concern expressed with the assumptions used in the study that might not be worst case in terms of transmit power levels or elevation angles. On this basis, further studies would be required before definitive conclusions can be reached.

It must also be noted that the current RR allow higher e.i.r.p. values to be transmitted in this band than the P-MP FS stations studied in this paper. Limits of 10 dBW on the transmit power and 55 dBW on the e.i.r.p. are specified in Article **S21** and Recommendation ITU-R SF.406, with no restriction placed on the bandwidth or elevation angle. Therefore, there may be a need to review the e.i.r.p. limits considering bandwidth and elevation angle for FS transmitters operating in this band.

3.1.4.3 Sharing between non-GSO FSS earth stations and fixed-service stations

The deployment needs of viable FS and FSS services range from sparse, low density to increasingly higher density. This affects the sharing conditions in terms of coordination between fixed stations and FSS earth stations. At one extreme is the low-density deployment of both services, which facilitates sharing. At the other extreme is the high-density deployment of both services, which creates the most difficult sharing environment. In this instance, either one or both services may be excessively constrained or prevented from offering a viable service in the same geographical area.

In the 10-30 GHz range, the fixed service applications are rapidly evolving to support cellular and PCS infrastructures as well as direct access to business and residential subscribers. There are also proposals for high-density FSS earth station applications. Some administrations are considering the authorization of such systems using area-wide (blanket) licensing. Such licensing schemes lead to a requirement for new approaches in order to facilitate sharing.

The case of sharing between FS and non-ubiquitous FSS earth stations can be handled through classical case-by-case coordination procedures which have already proved to work successfully. In the case of deployment of ubiquitous FSS terminals, in principle, the use of mitigation techniques by one or both services improves the ability of those services to share the same frequency bands.

The feasibility of potential mitigation techniques and their relative effectiveness are currently being studied. This involves a wide range of technical, economic and regulatory trade-offs. In cases where mitigation is insufficient or not practicable in those bands that are already or planned to be heavily used by the one type of service, possible solutions range from frequency separation to constraining the introduction of the other type of service to low-density, non-ubiquitous applications. However, so far, there is no practical experience to demonstrate fully unconstrained, co-frequency deployment of both FS and non-GSO FSS terminals is feasible, where the deployment of either system is of an ubiquitous nature. Furthermore, as the density of either service grows, the effectiveness of mitigation techniques decreases.

If either the FS or FSS deploys terminals in an unconstrained ubiquitous manner, co-frequency sharing in the same geographic area would be very difficult. However, this is a national issue except in the vicinity of international borders, where coordination between administrations may be required.

3.1.4.4 Sharing between non-GSO FSS and RLS, RNS and SRS in the bands 13.75-14 GHz and 17.3-17.7 GHz

3.1.4.4.1 Characteristics of the non-GSO FSS, radiolocation, radionavigation and space research systems

13.75-14.0 GHz

The band 13.75-14 GHz is allocated on a co-primary basis to FSS, RLS. It is also allocated, in some countries, to FS and MS (Nos. **S5.499** and **S5.500**) and to RNS (No. **S5.501**). GSO systems of SRS use this band in accordance with No. **S5.503**. Additionally, non-GSO SRS and EESS operate with protection from the FSS (No. **S5.503A**) until 1 January 2000. After 2001 the only space research system that will remain in the band on a co-primary basis with the FSS is the DRS system. For the sharing between FSS, RLS, RNS and SRS, the 13.75-14 GHz band can be split as follows:

- 13.75-13.8 GHz: FSS uplinks, RNS, radiolocation emissions and GSO-DRS links to both earth stations and LEO spacecraft (e.g. Shuttle);
- 13.8-14 GHz: FSS uplinks, RNS, radiolocation emissions and GSO-DRS links to earth stations only.

Technical and operational characteristics of radiolocation stations in the band 13.75-14 GHz are described in Recommendation ITU-R S.1068. These radars have peak e.i.r.p.s of 79 dBW and average e.i.r.p.s of 59 dBW and operate in both scanning and tracking modes. They are predominately shipborne radars, but some are land based. It is estimated that there are about 600 radars of this type in operational use.

17.3-17.7 GHz

The band 17.3-17.7 GHz is allocated to the RLS on a secondary basis, to FSS on a primary basis (limited by **S5.516** to BSS feeder links) and, in Region 2, to the BSS beginning 1 April 2007. Numerous types of radiolocation stations operate in the band 17.3-17.7 GHz. These stations include ship, ground and airborne equipment, some of which are tracking objects in space. These space-tracking radars could cause an instantaneous e.i.r.p. of 116 dBW to be directed at a satellite and may at times track it. These radars are also pointed at zenith and off-zenith for lengthy periods to provide maintenance of the space object catalog and data for space debris analysis and mapping. Although there are no limits imposed on radars in the band 17.3-17.7 GHz, sharing between BSS feeder links

and the RLS is currently feasible if the radiolocation service limits the e.i.r.p. towards the GSO to approximately 50 dBW. Emissions could be 66 dB higher toward a non-GSO satellite than toward the GSO.

3.1.4.4.2 Protection criteria

At WARC-92 and WRC-95, Nos. **S5.502, S5.503** and **S5.503A** were added to the Table of Frequency Allocations to facilitate compatibility between the existing applications in these services. It was agreed that any modifications to any of these footnotes in order to accommodate new technology, new requirements and applications of the FSS should consider the overall interference environment in the 13.75-14 GHz band and be undertaken with great care in order to avoid upsetting the delicate balance previously achieved between the services. The present operational constraints, that satisfy the protection criteria of current operational applications and technology in the band 13.75-14 GHz, are to be found in Nos. **S5.502** and **S5.503**.

The protection criteria of the space research links used are those included in Recommendation ITU-R SA.1155.

3.1.4.4.3 Methodologies used to assess the adequacy of the protection of non-GSO FSS, RLS, RNS and SRS

Regarding the impact of radiolocation transmissions on non-GSO FSS applications, the methodology used is similar to that given in Recommendation ITU-R S.1068, assuming the characteristics given in that Recommendation together with additional parameters provided by relevant ITU-R Study Groups. Extensive analyses were also performed on space science and non-GSO FSS systems compatibility based on the space research and F-SAT MULTI 1B characteristics.

3.1.4.4.4 Results of studies

These technical analyses have led to possible solutions which will maintain the present balance in the sharing conditions between radiolocation, space science and FSS, and accommodate non-GSO/FSS systems within the 13.75-14 GHz band.

With reference to No. **S5.502**, reduction or suppression of the minimum e.i.r.p. requirement for FSS earth stations coupled with appropriate regulatory measures to address the concerns of the radiolocation services, could achieve this objective. Under the current provisions, provided a radar observes the restriction put on its maximum e.i.r.p. averaged over 1 second, the FSS cannot claim protection from the radiolocation service regardless of the FSS earth station e.i.r.p. used.

Further analyis is needed to better define the interference environment of non-GSO FSS systems with regard to radiolocation emissions. In reviewing the radar characteristics provided in Recommendation ITU-R S.1068, clarification is needed on the possibility of extending the maximum e.i.r.p. averaged over one second from the GSO arc direction to the whole space.

In the case of footnote No. **S5.503** the present balance could be maintained through the addition of a maximum e.i.r.p. requirement of 51 dB(W/6 MHz) and a minimum antenna diameter of 4.5 m placed on the non-GSO FSS earth station in the band 13.772-13.778 GHz, combined with other appropriate regulatory provisions taking into consideration the overall interference environment in the 13.75-14 GHz band.

Other possibilities have been considered in order to assess how a relaxation of present operational constraints on the different services could be obtained and how more flexibility could be afforded to

the different applications within the services. These possibilities require further studies within the ITU-R. Information was given that future development of radars in this band may need a higher average e.i.r.p. limit, the impact of which would require a study. Some studies have been brought to the attention of the CPM about the sharing conditions between GSO FSS services and radiolocation in the band 13.75-14 GHz and between GSO FSS services and space research in the band 13.772-13.778 GHz. These studies related to the possible relaxation of the minimum antenna diameter of 4.5 m contained in footnote **S5.502**. Reconsideration of this limit requires further study within ITU-R.

In the band 17.3-17.7 GHz some analyses have been carried out on the basis of the radar characteristics available. Under the assumptions that there were few high power radars (maximum e.i.r.p. 116 dBW) and that the maximum pulse duration was 256 μs, it was found that a system like F-SAT MULTI 1B could handle such interference. Since these radars may at times track non-GSO space stations, more information needs to be made available on the operational characteristics of the high power radars in order to determine more accurately the impact of the radar on non-GSO FSS systems.

3.1.4.5 Regulatory and procedural considerations

3.1.4.5.1 Fixed service and non-GSO FSS systems

Resolution **131 (WRC-97)** invites ITU-R to study the appropriate pfd values to be applied to non-GSO networks in the bands 10.7-12.75 GHz and 17.7-19.3 GHz to ensure protection of the fixed service without unduly constraining the development of either type of network. Additionally, text is needed to reflect *resolves* 2 of Resolution **131 (WRC-97)** in Article **S.21**. Annex 4 provides an example of possible modifications of Article **S21**, Table **S21-4** including consideration of *resolves* 2 of Resolution **131 (WRC-97)**.

3.1.5 Identification and validation of software which could be used by the BR to check whether a system for which application for spectrum has been made would comply with the APFD and EPFD limits

The equivalent power flux-density (EPFD) limits apply to the sum of all emissions from the space stations (for $EPFD_{down}$ or $EPFD_{is}$) and earth stations (for $EPFD_{up}$) of a non-geostationary orbit (non-GSO) satellite system. Furthermore, the limits are specified for various percentages of time and as a function of GSO antenna characteristics. This complex combination precludes the use of a formula to determine compliance with the limits. Software can be used to accumulate the statistics of EPFD for any proposed non-GSO system and then compare these statistics with the limits and time percentages in the RR. Draft new Recommendation ITU-R BO.[Doc. 11/136] provides a functional description of the BR software, including sections on testing, documentation, and verification of the software. One or more candidate software programs that comply with this specification should be available for BR to evaluate prior to WRC-2000 and selection of software to be used for EPFD compliance testing should be approved at WRC-2000.

3.1.5.1 Summary of specification for the software

Draft new Recommendation ITU-R BO.[Doc. 11/136] provides the specification for the software which the BR/ITU would use to verify that a non-GSO network meets the $EPFD_{down}$/$EPFD_{up}$/$EPFD_{is}$ limits. This specification has been made available to administrations.

A software implementation that includes all the inputs, functions, and outputs described draft new Recommendation ITU-R BO.[Doc. 11/136] would enable BR to check compliance of any non-GSO system with the EPFD limits. Input parameters include the following:

- reference parameters (earth station and space station reference antenna radiation patterns, etc.);
- inputs from the appendix **S4** supplied by the administration for the non-GSO system;
- GSO earth station location test points.

The block diagram of the software algorithm is shown in Fig. 3-3. It consists of two sections: that of Initial Data and that of Calculation. The Initial Data Section contains the whole set of parameters relevant to the notified non-GSO satellite system, a set of reference GSO system parameters as well as $EPFD_{down}/EPFD_{up}/EPFD_{is}$ limits. The Calculation Section is designed for estimations required to examine notified non-GSO systems compliance with the $EPFD_{down}/EPFD_{up}/EPFD_{is}$ limits. The Calculation Section is based on a concept of a downlink pfd mask[2], an uplink e.i.r.p. mask[3], and an inter-satellite pfd mask[4].

A pfd/e.i.r.p. mask is calculated in Block 1 based on the notified non-GSO system parameters delivered from the Initial Data Section. Block 4 tests the aggregate interference produced by non-GSO network stations for meeting $EPFD_{down}/EPFD_{up}/EPFD_{is}$ limits. The verification in Block 4 is effected on the basis of the non-GSO system constellation characteristics from the Initial Data Section, a pfd/e.i.r.p. mask from Block 1 and output data from Block 3. The output data are verified for validity in Block 2.

Taking into account the significant complexity regarding specific features of different non-GSO system configurations in the software it would seem appropriate to impose some burden of responsibility relevant to testing for $EPFD_{down}/EPFD_{up}/EPFD_{is}$ limits on administrations notifying appropriate non-GSO systems. Therefore the examination procedure for meeting $EPFD_{down}/EPFD_{up}/EPFD_{is}$ limits would consist of two stages. The first stage would include the software development (Block 1) and conducting all the calculations by the administrations notifying non-GSO satellite systems. The stage would also include estimation of a mask for pfd/e.i.r.p. produced by interfering non-GSO network stations. The mask would account for all the features of specific non-GSO systems arrangements. The first stage would be finalized with delivering the pfd/e.i.r.p. mask in analytical or documented formats to the BR/ITU. Moreover the notifying administration would provide the BR/ITU with the software used in Block 1 for the pfd/e.i.r.p. mask estimation, the complete software description and parameters from Block "a": the information will also be available to other administrations.

The second stage calculations would be effected at the BR/ITU. The second stage would feature the following operations:

1) Definition of the maximum EPFD geometry of a GSO space station and an earth station of that network (Block 3). It would ensure verification of sharing feasibility for a notified non-GSO network with any GSO network in the FSS and BSS.

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[2] A pfd mask is the maximum pfd produced by a non-GSO space station.

[3] An e.i.r.p. mask is the maximum e.i.r.p. radiated by a non-GSO earth station and is a function of the off-axis angle from the transmitting antenna main beam.

[4] This is the maximum e.i.r.p. radiated by a non-GSO space station and is a function of the off-axis angle from the transmitting antenna main beam.

2) $EPFD_{down}/EPFD_{up}/EPFD_{is}$ statistics estimation (Block 4).

3) Software results verification for validity (Block 2).

4) Making a decision on interference compliance with $EPFD_{down}/EPFD_{up}/EPFD_{is}$ limits (Block 4).

The estimations are based on the non-GSO system parameters (Block "a") delivered by a notifying administration and the initial data (Block "b") available at the BR/ITU.

Any administration may use as required software that uses the algorithms defined in this document together with data on the non-GSO networks to estimate statistics for interference into its own GSO networks and check for compliance with $EPFD_{down}/EPFD_{up}/EPFD_{is}$ limits.

For checking compliance with these limits, BR will use certain increments and will test against the more fractionally severe value. For example, if the increment is 0.1 dB, where the $EPFD_{down}$ limit is -165.841 dB(W/(m^2.40 kHz)) the software will test against a criterion of -165.9 dB(W/(m^2.40 kHz)). The same rules should be applied when computing the $EPFD_{down}$ statistics.

3.1.5.2 Software validation process

Several administrations and other organizations are understood to be developing such software.

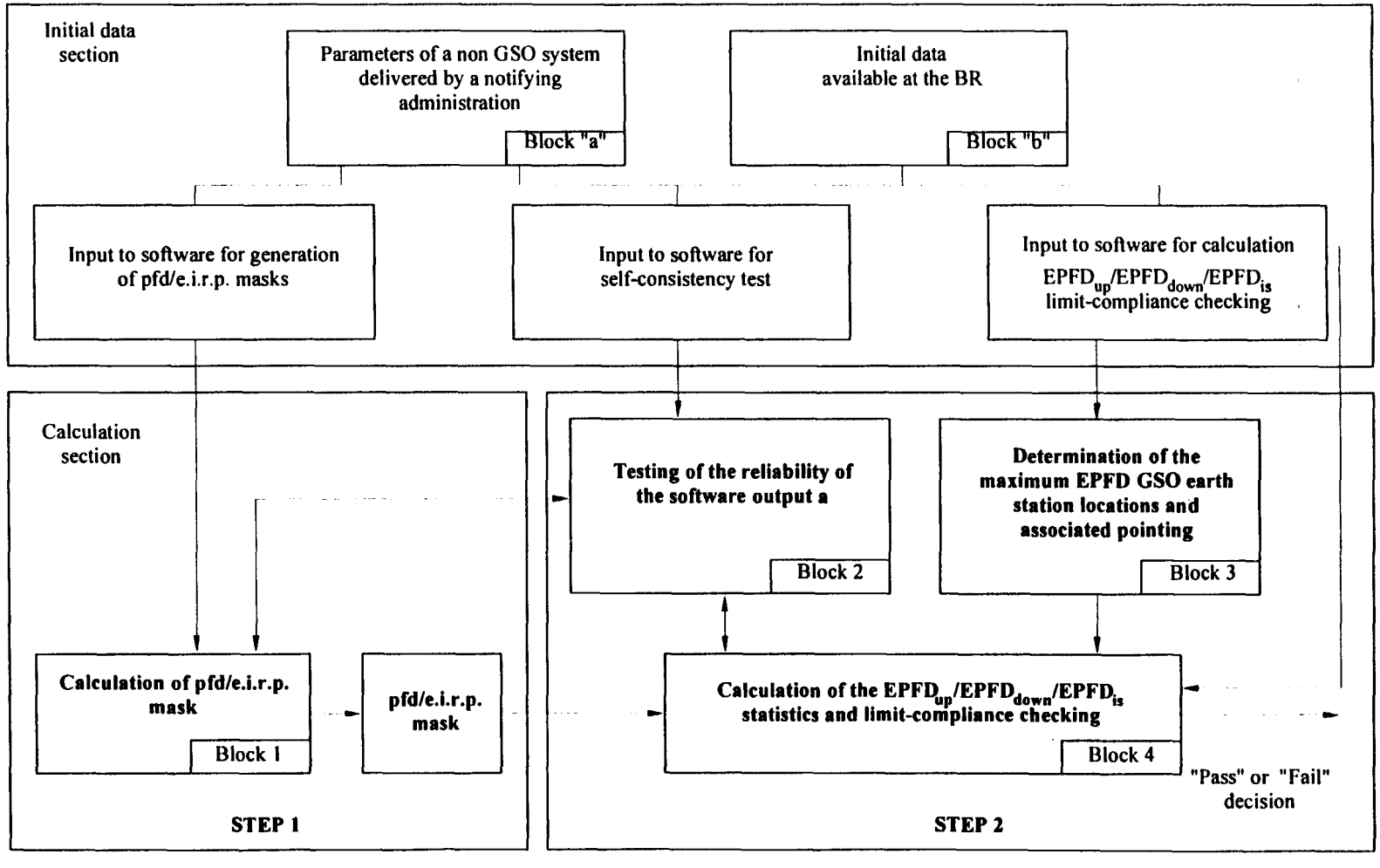
The candidate software shall be tested for accuracy using the guidelines stated in Annex 1 of draft new Recommendation ITU-R S.[Doc. 11/136]. The procedures given in draft new Recommendation ITU-R S.[11/136] shall be used for the validation of the candidate software.

In order to allow sufficient time for the BR to evaluate the candidate software and prepare its report, administrations have been requested to supply the candidate software to the BR by mid-January 2000.

3.1.5.3 Further work required

Upgrading of the software would be necessary to take account of decisions of future radio conferences.

FIGURE 3-3



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3.1.6 Regulatory procedures for the implementation of aggregate and operational limits

3.1.6.1 Aggregate limits

Section 3.1.1.3.2 identifies the need for a regulatory mechanism that would ensure protection of GSO FSS and GSO BSS networks from the maximum aggregate equivalent power flux-density produced by multiple non-GSO FSS systems in frequency bands where EPFD validation limits have been adopted. One possible mechanism for meeting this objective is a WRC-2000 Resolution that would take the form of the example draft Resolution (example Resolution **WWW**).

It was noted that Resolution **WWW** involves circumstances where several non-GSO administrations may need to jointly address interference concerns where it may be difficult for them to collectively resolve the problems in an expeditious manner. Furthermore, there is no recourse in the case of inability to reach agreement. An example procedure is included as section 1 in Annex 8 to this Chapter.

It is noted that in Steps 2) and 6) of section 1 in Annex 8, there are references to an [X] day period representing the requirement for "expeditious" resolution of an excess operational EPFD situation. The value of X is not yet agreed, but it should reflect the need for expeditious action, taking into account administrative and mailing delays.

Also, in section 1 in Annex 8, no conclusion was reached in the case of an administration failing to respond to BR request for cooperation. There needs to be further discussion on choosing the appropriate remedial measures, for the purpose of including such measures as Step 8) in the procedure. Some administrations were of the view that Step 8) could be replaced by the following: "In case the administration fails to respond to BR's request for information, BR shall commence with proceedings to cancel the entry of the relevant non-GSO network(s) from the Master Register". The view was also expressed that the procedures should be included in Article **S15**, or in a new stand-alone Article **[S15A]** or in a WRC Resolution. A further view was expressed that such procedures should be extended to any situation where permissible/accepted interference levels are exceeded or where the provisions of No. **S22.2** are not satisfied.

Administrations as well as BR are invited to review the practicability of the procedure outlined.

3.1.6.2 Operational limits

Section 3.1.2.4.7 defines "Operational Limits" to the $EPFD_{down}$ by non-GSO systems in certain frequency bands. This section also notes that additional regulatory work to develop a procedure based on this concept may be needed. In order to implement the operational limit concept, a procedure is needed which: i) identifies non-GSO systems exceeding the operational limits; and ii) ensures immediate reduction of the interference level to the operational limits by any non-GSO system exceeding those limits. It may be appropriate for this procedure to include the possibility of arriving at an alternative permanent solution acceptable to both parties. An example procedure is given in section 2 to Annex 8 to this Chapter.

Also, no conclusion was reached in the case of an administration failing to respond to BR request for cooperation. There needs to be further discussion on choosing the appropriate remedial measures, for the purpose of including such measures as Step 7) in the procedure in section 2 to Annex 8. Some administrations were of the view that Step 7) could be replaced by the following: "In case the administration fails to respond to BR's request for information, BR shall commence with proceedings to cancel the entry of the relevant non-GSO network(s) from the Master Register". The view was also expressed that the procedures should be included in Article **S15**, or in a new

stand-alone Article **[S15A]** or in a WRC Resolution. A further view was expressed that such procedures should be extended to any situation where permissible/accepted interference levels are exceeded or where the provisions of No. **S22.2** are not satisfied.

Administrations as well as BR are invited to review the practicability of the procedure outlined.

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3.2 Agenda item 1.13.2

"to consider the inclusion in other frequency bands of similar limits in Articles **S21** and **S22**, or other regulatory approaches to be applied in relation to sharing situations"

3.2.1 Sharing considerations between non-GSO FSS and GSO BSS receive earth stations in the 17.3-17.8 GHz band

Resolution **538 (WRC-97)** introduced provisional EPFD and $EPFD_{up}$ limits for non-GSO FSS systems in certain bands intended to protect GSO BSS systems. Resolution **538 (WRC-97)** did not designate use of the 17.3-17.8 GHz band in Region 2 by non-GSO FSS, stating that such use required further study as to the feasibility of non-GSO FSS to share with the allocated BSS service in this band. The ITU-R considered the sharing situations identified in Resolution **538 (WRC-97)**.

Regarding sharing between transmit GSO BSS space stations and receive non-GSO FSS space stations, it was concluded that there would be no need for specific provisions since the sharing situation would be similar to that existing between GSO FSS transmit space stations and non-GSO FSS receive space stations in the adjacent band 17.8-18.4 GHz.

Regarding the feasibility of sharing between transmitting non-GSO FSS earth stations and ubiquitous BSS receive earth stations in the 17.3-17.8 GHz band, it was noted that this situation would require coordination, using the existing provisions under **S9.17A**, between the administrations on the territories of which the non-GSO FSS transmitting earth stations and BSS receive earth stations are located. It was also noted that the frequency band 17.7-17.8 GHz is also allocated to the fixed-satellite service (space-to-Earth).

It was concluded that sharing is not feasible between ubiquitous non-GSO FSS user terminals and ubiquitous BSS receive terminals located in the same geographical area.

Regarding non-GSO gateway operation, the studies reported to the ITU-R concluded that the coordination distance with BSS receive terminals would be the default value of 100 km. This means that coordination would have to take place between administrations when the distance between a non-GSO gateway and the territory of another administration intending to deploy BSS receive terminals is smaller than 100 km. During this coordination the separation distances required to avoid unacceptable interference would be assessed.

One study determined the separation distance to be between 15.8 and 93.9 km for non-GSO FSS gateways for the particular system studied (F-SAT MULTI 1B).

It was based on:

- A steady state long-term protection criterion of I/N = -18 dB. This value was selected to provide sufficient protection of the GSO BSS from non-GSO FSS when the interfering source is not time varying.
- A 2.5 m non-GSO gateway antenna with a minimum 10° elevation angle.

- Use of both a worst-case and best-case relative azimuth angle between the source and victim antennas, bounding the time varying nature of the interference.
- A free space loss propagation model.

Further analysis was performed based on ITU-R agreed protection criteria developed for sharing between GSO BSS and non-GSO FSS downlinks again assuming the non-GSO FSS earth station operates at 10° minimum elevation angle. The I/N value used in the calculations corresponds to an increase in unavailability of the BSS link of 2.86% (10% ÷ 3.5 effective non-GSO FSS systems).

Using this long-term criteria, this study calculated a separation distance of 65 km. It was noted that the acceptable interference level used was derived assuming the wanted and interfering signals were equally faded. In actual practice, the BSS signal can be faded while the gateway interference may not be faded. This will lead to the need for larger separation distances.

Another study to assess the required separation distance considered the same non-GSO FSS system (F-SAT MULTI 1B) and was based on:

- the statistical method included in the draft new Recommendation ITU-R S.[Doc. 4/60] that is being considered for possible inclusion in Appendix **S7** to deal with non-GSO FSS earth station interference; and
- the I/N criterion of 8 dB not to be exceeded for more than 0.003% of the time. This I/N is 1.3 dB less conservative than the upper bound I/N range of the current preliminary criteria to calculate the coordination contour.

This study concluded that, for a 0° horizon elevation around a non-GSO FSS gateway, the separation distances for the gateways of this particular system are typically 20 km, ranging from 1 km to 45 km, depending on the azimuths considered around the gateway. It also showed that, for a particular case assuming a 1° horizon elevation around the gateway in every direction (i.e. 20 m horizon height at a 1 km distance), this separation distance would fall to 1 km in all directions.

The difference in the results of the above studies are due to the difference in BSS criteria, propagation models and methodologies used. These criteria and methodologies used for separation distance calculation, are provisional pending the adoption of final criteria and methodologies within ITU-R.

One result from these studies is that in order to avoid interference from non-GSO gateway terminals within or near a BSS service area, some separation distance is required between the gateway terminal and ubiquitously deployed BSS receive terminals. BSS user terminals located closer to the non-GSO gateway terminal than the required separation distance would not receive unconstrained interference-free service. These terminals would require special treatment on an installation-by-installation basis to ensure service to all BSS users.[5]

Views were expressed that, since the BSS, by definition, is intended for general reception by the public and therefore dependent on the ability to ubiquitously deploy receive earth stations, reception within the BSS service area should not be limited or restricted, therefore non-GSO FSS use of the 17.3-17.8 GHz band in Region 2 would not be feasible.

[5] BSS receive terminals that will operate in the 17.3-17.8 GHz band may have to share the band with Appendix **S30A** BSS feeder-link earth stations depending upon the implementation of BSS in the 17 GHz band by each Region 2 administration. The BSS feeder links are quite limited in number, operate towards relatively fixed positions in space, and typically not towards the horizon. The band 17.7-17.8 GHz is also allocated to the FSS (s-E) and the FS.

Several views were also expressed that, given that the number of non-GSO FSS gateways proposed in this band would not be large, and given the small separation distances shown in the second study, the use of non-GSO FSS gateway transmit earth stations in this band would be feasible without undue constraints on the development of GSO BSS.

3.2.2 Frequency band 17.3-17.8 GHz

The question was raised as to whether the 17.3-17.8 GHz band was allocated for use by the non-GSO FSS in Region 2 at WRC-97. Reference was made to footnote **S5.516** which states:

S5.516 The use of the band 17.3-18.1 GHz by geostationary-satellite systems in the fixed-satellite service (Earth-to-space) is limited to feeder links for the broadcasting-satellite service. For the use of the band 17.3-17.8 GHz in Region 2 by feeder links for the broadcasting-satellite service in the band 12.2-12.7 GHz, see Article **S11**. The use of the bands 17.3-18.1 GHz (Earth-to-space) in Regions 1 and 3 and 17.8-18.1 GHz (Earth-to-space) in Region 2 by non-geostationary-satellite systems in the fixed-satellite service is subject to the provisions of Resolution **538 (WRC-97)**.

Some administrations consider that it was not the intent of WRC-97 to make this band available for the non-GSO FSS (uplink) in Region 2 and that this allocation is not effected by the footnote.

Other administrations consider the footnote to mean that an allocation is available in this band for non-GSO FSS (uplink) use and that only further sharing studies are required.

The question was submitted by one administration to the RRB requesting the Board to prepare a Rule of Procedure stating that the band 17.3-17.8 GHz is not allocated to the non-GSO FSS (uplink) in Region 2. At the Board's 18th meeting 8-12 November 1999 the Board considered this matter and concluded that "***... a Rule of Procedure was not necessary in this case***". Presumably it is being left to WRC-2000 to take any action that is deemed necessary on this matter.

Should WRC-2000 decide that the band 17.3-17.8 GHz is allocated to non-GSO FSS (uplink) in Region 2 it is proposed that the -160 dB(W/(m^2.40 kHz)) EPFD$_{up}$ limit should also be applicable to the frequency band 17.3-17.8 GHz (Region 2) in order to protect BSS feeder links from non-GSO FSS (uplinks) in Region 2 (see also 3.1.3.1.4).

It was recognized that there is currently an allocation to BSS in Region 2 in the frequency band 17.3-17.8 GHz, allocation entering into effect on 1 April 2007 (No. **S5.517**). If power limits were to be used for sharing between non-GSO BSS systems in Region 2 and GSO BSS feeder links, the single entry EPFD$_{is}$ applicable to the frequency band 17.8-18.1 GHz (-160 dB(W/m^2·40 kHz) would be appropriate in the frequency band 17.3-18.1 GHz.

3.2.3 18.1-18.4 GHz band

The ITU-R examined the possibility of applying EPFD$_{up}$ limits in the band 18.1-18.4 GHz, intended to protect GSO BSS feeder links in this band from interference caused by non-GSO FSS systems operating in the Earth-to-space direction.

It was noted that the sharing and regulatory situations in the 17.8-18.1 GHz band and in the 18.1-18.4 GHz band currently differ only on the following aspects:

- In the 17.8-18.1 GHz band, sharing between BSS feeder links and non-GSO FSS (Earth-to-space) is effected by the EPFD$_{up}$ limits which have been reviewed ITU-R.
- In the 18.1-18.4 GHz band, sharing between BSS feeder links and non-GSO FSS (Earth-to-space) is effected by the application of No. **S22.2**.

As No. **S5.520** currently restricts the use of this band by FSS (Earth-to-space) to BSS feeder links, the use of this band by non-GSO FSS (Earth-to-space) other than BSS feeder links would therefore require a modification to this footnote.

It was also concluded that there would be a need to include $EPFD_{up}$ limits in Article **S22** to protect GSO BSS feeder links in this band, if WRC-2000 decides that this band may be used by non-GSO FSS Earth-to-space other than BSS feeder links. The level considered appropriate for these limits to protect GSO BSS feeder links is that proposed by in Annex 1 for the $EPFD_{up}$ limits in the adjacent band (17.8-18.1 GHz) and for $EPFD_{is}$ limits in the 18.1-18.4 GHz band.

The ITU-R also noted that no regulatory approaches other than the power limits approach were studied or proposed for this band. Regulatory approaches other than power limits may also be considered.

Concerns were raised about the impact of coordination distances required between non-GSO FSS transmitting earth stations and receiving FSS earth stations on the ability to ubiquitously deploy receiving terminals in the FSS in this band. It was noted however, that the selection of either type of service in a particular country is a matter of national decisions. In the case of non-GSO FSS transmitting gateways, coexistence with other FSS receiving terminals in neighbouring countries could be ensured through bilateral coordination, when necessary.

With regard to the fixed service, studies have been undertaken to evaluate the interference from fixed service systems into non-GSO FSS space stations in the 18.1-18.4 GHz band, where the two services are allocated on a co-primary basis. The studies were based on the characteristics of typical FS point-to-point systems and on the characteristics of the space stations of the F-SAT MULTI 1B non-GSO FSS system. The study concluded that, even under pessimistic assumptions, the interference from FS systems into non-GSO FSS (Earth-to-space) in the 18.1-18.4 GHz frequency range would be acceptable. However, the ITU-R notes that studies on the potential interference to FS receiving stations from non-GSO FSS transmitters have not been completed. . Therefore, the possible introduction of limits in the 18.1-18.4 GHz band would be considered after these studies have been completed.

3.2.4 Frequency outside of range 10-30 GHz

When it adopted Resolution **130 (WRC-97)** and the provisional limits that would apply to non-GSO FSS systems in certain bands between 10 and 30 GHz, WRC-97 determined that for these specific bands, non-GSO systems in the FSS should bear more of the burden of accommodating sharing than should co-frequency GSO FSS systems. WRC-97 did not decide how to assign sharing burdens between GSO and non-GSO systems in any FSS bands above 30 GHz or below 10 GHz, but instead requested that the ITU-R "undertake the development of power limits or other frequency sharing mechanisms" - at least in such bands where non-GSO FSS systems are likely to be implemented and GSO systems are used or expected to be used extensively. This direction is consistent with § 4.3.7.2 of the CPM-97 Report, which recognized that a power limits approach of the type that is now reflected in Resolution **130 (WRC-97)** "is not suited for sharing situations where more burden would be placed on the GSO FSS systems or the burden would be equally shared between the GSO and non-GSO ... systems," and that the "establishment of e.i.r.p. and pfd limits may not be a suitable approach for all types of non-GSO ... networks in every FSS band."
There are fundamental differences between the situation in the 10-30 GHz FSS bands identified in Resolution **130 (WRC-97)** where a non-GSO FSS service concept is being overlaid upon an existing and/or imminent GSO FSS service and other bands where both GSO and non-GSO FSS systems are just now beginning to emerge. In these 10-30 GHz bands, there is extensive deployment

or long-standing development of GSO systems and GSO operators have limited or no flexibility to adjust to the introduction of non-GSO systems. In these bands, non-GSO systems must thus bear most or all of the burden of implementing technical criteria to protect the GSO arc. In bands where there has been little or no deployment of satellite systems to date and satellite networks (GSO and non-GSO alike) have only recently begun to be communicated to ITU-R, the absence of current and imminent use by GSO and non-GSO FSS systems means that both types of operators should expect to exhibit greater flexibility in achieving the appropriate balance among the competing technical, regulatory and policy considerations that will affect their sharing environment.

Technical studies of interference mitigation techniques that may be employed by non-GSO and/or GSO FSS operators in bands outside 10-30 GHz to enable co-frequency sharing are under way in ITU-R. Simulation results on a planned non-GSO FSS system in the 40-50 GHz band were provided, analysing the impact of two mitigation techniques. The first set of results assumed polarization discrimination between the GSO and the non-GSO systems. To use this mitigation technique, the non-GSO system has to be on the opposite polarization from every GSO system with which it will have in-line events. The second set of results assumes that the GSO satellite can also use satellite diversity as an interference mitigation technique. This technique would improve the GSO link availability and increase the system capacity because the propagation impairments at these frequency bands are severe. Both techniques proved to be efficient in mitigating the mainbeam-to-mainbeam interference that can appear between non-GSO and GSO systems operating co-frequency in these bands. However, both would constrain the GSO FSS to either use only one polarization or to double the number of satellites required.

Although the techniques examined in bands outside 10-30 GHz offer promise in mitigating the mainbeam-to-mainbeam interference that can appear between co-frequency non-GSO and GSO systems, further work needs to be done on these potential mitigation techniques and other approaches and refinements that have yet to be addressed within ITU-R. Matters that remain to be addressed in these bands include whether there would be coordination between non-GSO and GSO systems, the appropriateness of retaining No. **S22.2**, the impact of other co-frequency services in a particular band on the GSO/non-GSO sharing situation and the impact of any regulatory approach for GSO and non-GSO sharing on innovation in all services in a particular band.

As a result, ITU-R is not in a position to make a final recommendation on whether power limits on the non-GSO FSS operator or some other frequency sharing mechanism or combination of mechanisms should be imposed to facilitate GSO/non-GSO FSS sharing in any FSS band outside the 10-30 GHz range. There is no technical basis at this time for extending to FSS bands above 30 GHz and below 10 GHz either the regulatory scheme that is established in Resolution **130 (WRC-97)** for certain FSS bands between 10 and 30 GHz or any other regulatory/procedural approach (e.g. Resolution **46 (Rev. WRC-97)/S9.11A**). The regulatory scheme in Resolutions **130 (WRC-97)** and **538 (WRC-97)** reflects the particular circumstances at 10-30 GHz and is inappropriate for application by default to the very different circumstances that exist in the FSS bands above 30 GHz and in certain of the FSS bands below 10 GHz.

Regarding the possible introduction of limits in bands outside of the range 10-30 GHz, insufficient proposals have been received by the ITU-R Study Groups to allow the introduction of limits or alternative regulatory approaches in other bands.

3.2.5 Other regulatory approaches

A number of studies considered by ITU-R presented the per-satellite pfd approach as an approach to enable sharing between GSO and non-GSO FSS systems. However, there is concern that the current form of per-satellite pfd limits would unacceptably constrain the design flexibility of non-GSO FSS

systems. Further study is required before this per-satellite pfd approach may be considered to be a viable regulatory option.